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PATENT

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re reissue application of:

Salcudean, *et al.*

Application No.: 09/307,023

Filed: 5/7/99

For: CONTROLLER

Examiner: K. Chang

Art Unit: 2673

SUPPLEMENTAL REISSUE DECLARATION UNDER 37 C.F.R. § 1.175(a) AND POWER OF ATTORNEY BY INVENTORS

Commissioner for Patents
Washington, D. C. 20231

Sir:

We, Septimiu Edmund Salcudean and Allan J. Kelley, state and declare the following:

1. We are citizens of Canada residing at 4338 West 2nd Avenue, Vancouver, British Columbia, Canada, V6R 1K3 and 306 - 1450 Laburnum St., Vancouver, BC V6J 3W3, respectively.

2. The entire right, title and interest to U.S. Patent No. 5,790,108, issued August 4, 1998 is vested in Immersion Corp., a Delaware corporation having a regular and established place of business at 801 Fox Lane, San Jose, CA 95131.

3. We verily believe ourselves to be the original, first, and joint inventors of the invention described and claimed in the above-identified United States Letters

Patent and in the present application for reissue of the above-identified United States Letter Patent.

4. We have reviewed and understand the contents of the attached specification and claims, including the amended and new claims as presented in this application for reissue of the original Letters Patent.

5. We acknowledge the duty to disclose information of which we are aware and which is material to the examination of this application for reissue of the original Letters Patent in accordance with 37 C.F.R. § 1.56, including information which was discovered between the filing date of United States Patent Application Serial No. 07/965,427 that matured into the Letters Patent for which reissue is being sought and the filing date of this application for reissue.

6. We verily believe that the original Letters Patent is partly or wholly inoperative or invalid by reason of our claiming more or less than we had a right to claim in the original Letters Patent, and that the errors described below which render said Letters Patent so partly or wholly inoperative or invalid occurred through inadvertence and/or omission without any fraudulent or deceptive intent on our part.

7. Every error in the patent which was corrected in the present reissue application, and is not covered by the prior declaration submitted in this application, arose without any deceptive intention on the part of the applicant.

8. More specifically, we believe that the original Letters Patent for which we seek reissue claims more or less than we had the right to claim for the following reasons:

8.1. Column 6, lines 50-63 and column 8, lines 29-38 and 47-65 of the original Letters Patent includes what we believe to be an accurate and proper characterization of an interface device including a separate microprocessor for use with a host computer, reproduced below:

> An embedded micro-controller 67 (see FIG. 1) may be used for controlling the motion sensing and force actuation of the system. This

micro-controller determines the movement of the platform as above described by the interruption of the beam 64 by the line grid. When motion is detected, the micro-controller 67 sends the appropriate information packet through a connection to the computer's mouse port where it is interrupted by that system's mouse driver in the same way as it would for a common mouse.

After calculating the position of the platform 14, the micro-controller's control program also calculates any necessary feedback forces and causes their actuation by turning on current drivers that excite one or both of the x and/or y direction coils 90.

Force feedback is applied to the handle 18, 140, or 168 is generated by programming a computer. For demonstration purposes the configuration shown in FIG. 11 was used wherein a first display station computer 200 was interconnected with a mouse controller 202 by two lines of serial communication 204 and 206 respective specifically a connection to the mouse port for supplying the work station with mouse motion data and a connection from a serial port for receiving commands and screen information from the work station. ...

Preferably the mouse 202 will send movement and button status data to the computer 200 where software calculates the desired forces for that particular pointer location and sends that force information to the micro controller which in turn drives the coils 90, 124 and 156 as required. However, this requires a very high powered computer and therefore to simplify to permit operation with the equipment available the computer 200 responsibilities were limited to handling the usual x window events, process input to maintain graphic interface and to initiate a synchronous transmission of non-real time commands to the micro controller when necessary. The micro controller is given the responsibility of doing the mouse position sensing to control movement and the transmission of mouse status data to the host mouse port and at the same time respond to commands

from the host 200 and store in memory the locations of icon, windows, buttons, etc. that are activated on the display and to interactively calculate the necessary feedback forces with respect to pointer or curser [sic] positions during control movements.

Column 7, lines 19-67 and column 8, lines 1-28 of the original Letters Patent includes what we believe to be an accurate and proper characterization of an interface device including a tactile feeback element, reproduced below:

> The mouse handle 18 is shown in exploded view in FIG. 6 and includes as above described an actuator button 20 and a tactile element 22. The button 20 actuates a micro switch 118 while the tactile element 22 is controlled by an E-core type magnet 122 with a coil as schematically indicated at 124.
>
> The structure of the tactile element is more clearly shown in FIG. 7 and includes an E-core magnet 122 with a coil 124 wrapped around its inner leg which is positioned to cooperate with a permanent magnet 126 mounted on the tactile element 22.
>
> A pair of springs 128 and 130 tend to hold the tactile element in its lower most position as illustrated i.e. closest to the core 122, however when the coil is activated the repulsion of the magnet 126 from the core 122 and the coil 124 is stronger than the tension in the springs 128 and 130 so that the tactile element moves upwardly away from the core 122 with the amount of movement being dependent on the current in the coil 124.
>
> The position of the tactile element 22 is such that it contacts with the hand of the user and when activated applies pressure thereagainst, the pressure being proportional to the amount of current passing through the coil 124.
>
> Other types of handles may be used if desired, for example, the control handle 131 in FIG. 8, which takes the form of a joystick control may also be used and may be provided with further controller buttons as schematically indicated at 132 and further tactile elements as indicated at 134, 136, and 138

on the joystick 140. Tactile elements may be operated in a similar manner to the tactile element 22 described above and the control elements 132 may take the form of pressure switches or the like.

8.2. The absence in the original Letters Patent of an independent claim in which an interface device enables a user to spatially navigate a displayed graphical menu with a displayed pointer, where the device includes a handle, a z-axis actuator applying forces to the user's hand only along a z-axis degree of freedom different from and substantially perpendicular to the two planar degrees of freedom, a sensor, a button, and an embedded microprocessor local to the interface device that sends handle movement data to the computer, receives desired force values from the host correlated with particular pointer locations displayed by the host, and controlling the z-axis actuator in accordance with the received desired force values so as to provide tactile sensations to the user correlated with location of the pointer in the graphical menu, such as is provided in new claim 19 below, resulted in the original Letters Patent claiming less than the applicant had a right to claim. At the time of drafting and prosecution of the application that matured into the original Letters Patent, we did not perceive that such a claim could be made.

8.3. To cure the aforementioned error of inadvertent omission, we therefore request the addition of a claim such as claim 19 below:

> 19. An interface device for enabling a user to spatially navigate a displayed graphical menu with a displayed graphical pointer, the graphical menu having a plurality of menu elements, and for enabling said user to more easily select a menu element from said graphical menu by providing tactile feedback to said user when said graphical pointer is moved from one menu element to the next menu element in said graphical menu, said interface device comprising:
>
> (a) a handle to be manipulated manually by a user in at least two planar degrees of freedom;
>
> (b) a z-axis actuator generating tactile sensations to be felt by said user, wherein said z-axis actuator applies forces to the user's hand only along a z-axis degree of freedom when current is flowed through a portion of said

actuator, said z-axis degree of freedom being different from and substantially perpendicular to said two planar degrees of freedom;

(c) a sensor that produces a locative signal responsive to and corresponding with the motion of said handle in said at least two degrees of freedom;

(d) a button that produces a status signal in response to being pressed by said user; and

(e) an embedded microprocessor local to said interface device and coupled to said sensor, to said button, and to said actuator, said microprocessor performing:

sending handle movement data and button data to a host computer over a communication bus such that said host computer can update displayed pointer locations with respect to said displayed graphical menu,

receiving desired force values from said host computer, said desired force values correlated with particular pointer locations displayed by said host computer, and

controlling said z-axis actuator in accordance with said received desired force values so as to provide said tactile sensations to said user that are correlated with the location of said displayed graphical pointer displayed within said graphical menu.

8.4. The addition of such a claim would cure our error of inadvertent omission by reciting a human interface device that includes a handle, a z-axis actuator, a sensor, and an embedded microprocessor, without the inclusion of elements which are not required to distinguish the invention over the prior art. In particular, this claim differs from the independent claim of the present Letters Patent by reciting, among other elements, a z-axis actuator and an embedded microprocessor receiving desired force values without the inclusion of other elements now understood not to be required to distinguish the invention recited in claim 19.

8.5. New dependent claim 20 would cure the inadvertent omission of a claim which recites that the actuator imparts the tactile sensations upon the handle along a z-axis orthogonal to the at least two degrees of freedom.

8.6. New dependent claim 21 would cure the inadvertent omission of a claim which recites the handle is physically coupled to a support mechanism that is grounded and allows linear displacement between the handle and an origin.

8.7. New dependent claims 22-24 would cure the inadvertent omission of claims which recite features of an optical sensor system including an emitter and detector, a light source projecting light upon a detector, a light source that moves when the handle is moved, and a detector that detects motion of the light source in two mutually perpendicular directions.

8.8. New dependent claims 27 and 28 would cure the inadvertent omission of claims which recite features such as memory that stores values representative of the locations of images displayed by the host computer, and that the locations include the locations of icons displayed by the host computer.

8.9. New dependent claims 29 and 30 would cure the inadvertent omission of claims which recite that the handle is a joystick and that the handle is a mouse.

8.10. New dependent claim 31 would cure the inadvertent omission of a claim which recites that the microprocessor receives display information from the host computer over the communication bus.

8.11. New dependent claims 32-34 would cure the inadvertent omission of claims which recite that the forces include a viscous drag force, that the forces include an attractive force, and that the attractive force is used to assist a user in positioning a displayed cursor into the graphical menu.

8.12. New dependent claims 37 and 38 would cure the inadvertent omission of claims which recite that the actuator is a flat coil actuator, and that the magnet associated with the flat coil actuator is fixed with respect to the origin and the coil moves with respect to the origin.

8.13. New dependent claim 39 would cure the inadvertent omission of a claim which recites that the microprocessor receives code over a communication bus from a

host computer and executes the code, where the communication bus includes a serial interface bus.

8.14. We further believe that the absence in said Letters Patent of an independent claim in which a device used in conjunction with a host computer, including a handle, a z-axis actuator applying forces to the user's hand only along a z-axis degree of freedom different from and substantially perpendicular to the two planar degrees of freedom, a sensor, a button, and control electronics sending handle movement data to the host, receiving a force value from the host, and controlling the actuator in accordance with the force value, claimed without the inclusion of other elements included in claims 1-18 of the original patent, such as is provided in new claim 41 below, is an error of inadvertent omission that occurred during the drafting and prosecution of the application that matured into the present Letters Patent. At the time of drafting and prosecution of the application that matured into the present Letters Patent, we did not perceive that a device that includes the above elements should be claimed independently, without the inclusion of other elements such as are included in claims 1-18 of the present Letters Patent. To cure the aforementioned error of inadvertent omission, we therefore request the addition of a claim such as claim 41 below:

> 41. A device for use in conjunction with a host computer including a computer display, said host computer displaying a graphical environment including a displayed graphical pointer controlled by said user, said device comprising:
>
> a handle to be manipulated manually by a user in at least two planar degrees of freedom;
>
> a z-axis actuator to generate a tactile sensation to be felt by said user, said z-axis actuator applying forces to the user's hand only along a z-axis degree of freedom when current is flowed through a portion of said actuator, said z-axis degree of freedom being different from and substantially perpendicular to said two planar degrees of freedom;
>
> a sensor that produces a locative signal responsive to and corresponding with a position or motion of said handle in said at least two degrees of freedom;

a button that produces a status signal in response to being pressed by said user; and

control electronics local to said device and coupled to said sensor and said actuator and said button, said microcontroller performing the following:

sending handle movement data and button data to a host computer over a communication bus such that said host computer can update a displayed pointer location in said displayed graphical environment,

receiving a force value from said host computer, said force value correlated with said updated displayed pointer location, and

controlling said z-axis actuator in accordance with said received force value so as to provide said tactile sensation to said user that is correlated with the location of said displayed graphical pointer displayed within said displayed graphical environment.

8.15. New dependent claims 42-45 would cure the inadvertent omission of claims which recite that the microcontroller runs a program contained, at least in part, in memory, where the memory also stores location information which corresponds with image data from a computer display coupled to the host computer, and that the location information includes information relating to the location of an icon on said graphical display, the location information includes information relating to the location of a window on said graphical display, and that the location information includes information relating to the location of a graphical button on said graphical display.

8.16. New dependent claims 46 and 47 would cure the inadvertent omission of claims which recite that the images include a cursor interacting with another object displayed on the computer display, and that the cursor interacts with an icon image displayed on the computer display.

8.17. New dependent claim 49 would cure the inadvertent omission of a claim which recites that the two degrees of freedom are linear degrees of freedom.

8.18. New dependent claim 51 would cure the inadvertent omission of a claim which recites that the microprocessor calculates force feedback forces based on received commands.

8.19. New dependent claims 52-53 would cure the inadvertent omission of claims which recite that the handle is moveable in a plane, and that the handle is also moveable along a z-axis that is approximately perpendicular to the plane

8.20. New dependent claim 54 would cure the inadvertent omission of a claim which recites that the control electronics include an embedded microcontroller.

8.21. New dependent claims 55-58 would cure the inadvertent omission of claims which recite that the tactile sensation is applied to correspond with the displayed pointer interacting with a displayed menu, and with a displayed button, with a displayed window, and with a displayed icon.

8.22. We further believe that the absence in said Letters Patent of an independent claim reciting an interface device for use with a host computer that commands force feedback sensations, the interface device including a physical object, at least one z-axis actuator, a sensor, a user-adjustable switch apparatus, and a microprocessor separate from the host computer which receives force values from the host correlated with locations of the pointer in a graphical environment, a state signal from the switch apparatus, and signals from the sensor, and a microprocessor executing a process in parallel with the host execution of the graphical application and providing the force signal to the actuator to impart forces in accordance with the force values to provide correlated tactile sensations with pointer location, claimed without the inclusion of other elements included in claims 1-18 of the original patent, such as is provided in new claim 59 below, is an error of inadvertent omission that occurred during the drafting and prosecution of the application that matured into the present Letters Patent. At the time of drafting and prosecution of the application that matured into the present Letters Patent, we did not perceive that a device that includes the above elements should be claimed independently, without the inclusion of other elements such as are included in claims 1-18 of the present Letters Patent. To cure the aforementioned error of inadvertent omission, we therefore request the addition of a claim such as claim 59 below:

59. An interface device for use with a host computer displaying a graphical application on a display device, said host computer displaying,

executing, and updating graphical objects in a graphical environment in response to user manipulation of said interface device and commanding force feedback sensations in response to said user manipulation and in coordination with said graphical objects, said graphical objects including a graphical pointer, the interface device comprising:

a physical object grasped and manipulatable by a user in two planar degees of freedom;

at least one z-axis actuator coupled to said physical object for receiving a force control signal and imparting forces along at least one degree of freedom of said physical object and in accordance with said force control signal, said forces applied along a z-axis degree of freedom that is different from and substantially perpendicular to said two planar degrees of freedom;

a sensor that detects motion of said physical object along said at least one degree of freedom and outputs signals relating to the position of said physical object;

a user-adjustable switch apparatus providing a state signal representing a state of said switch apparatus; and

a microprocessor local to said interface apparatus, separate from said host computer, and coupled to said host computer, to said sensor, and to said switch apparatus, said microprocessor receiving

force values from said host computer, said force values correlated with particular locations of said graphical pointer in said graphical environment displayed by said host computer,

said state signal from said switch apparatus, and

said signals from said sensor,

said microprocessor executing a process in parallel with said host execution of said graphical application and providing said force control signal to said at least one actuator to impart said forces in accordance with said received force values so as to provide tactile sensations to said user that are correlated with the location of said displayed graphical pointer.

8.23. New dependent claim 60 would cure the inadvertent omission of a claim which recites that the graphical objects include a dispplayed graphical menu, where the tactile sensations enable the user to more easily select a menu element.

8.24. We further believe that the absence in said Letters Patent of an independent claim reciting a method for controlling a force feedback interface device including sending a position signal to a host computer, receiving a force value from the host computer by a local microprocessor, and controlling a z-axis actuator in accordance with the received force value, claimed without the inclusion of other elements included in claims 1-18 of the original patent, such as is provided in new claim 63 below, is an error of inadvertent omission that occurred during the drafting and prosecution of the application that matured into the present Letters Patent. At the time of drafting and prosecution of the application that matured into the present Letters Patent, we did not perceive that a method that includes the above elements should be claimed independently, without the inclusion of other elements such as are included in claims 1-18 of the present Letters Patent. To cure the aforementioned error of inadvertent omission, we therefore request the addition of a claim such as claim 63 below:

> 63. A method for controlling a force feedback interface device using a host computer, said interface device manipulated by a user, a display device coupled to said host computer displaying a graphical user interface including images and updating said graphical user interface in response to said manipulation of said interface device, said interface device conveying force feedback sensations to said user in response to said manipulations, the method comprising:
>
> sending a position signal to said host computer, said position signal including information representative of the motion or position of a handle of said interface device in two planar degrees of freedom, said handle being physically manipulated by said user, wherein said host computer updates the location of a cursor within said graphical user interface in response to said position signal;
>
> receiving a force value from said host computer with a microprocessor local to said force feedback interface device, said force value correlated with said location of said cursor; and
>
> controlling a z-axis actuator in accordance with said received force value to provide a tactile sensation to said user that is correlated with said location of said cursor in said graphical user interface, said tactile sensation being applied to the user's hand along a z-axis degree of freedom, said z-axis

degree of freedom being different from and substantially perpendicular to said two planar degrees of freedom.

8.25. New dependent claim 64 would cure the inadvertent omission of a claim which recites that a sensor signal is input to the microprocessor, the microprocessor calculating the position signal based on the sensor signal, the microprocessor sending the position signal to the host computer.

8.26. New dependent claim 65 would cure the inadvertent omission of a claim which recites that the handle includes a joystick that can be moved by the user in two degrees of freedom.

8.27. New dependent claim 66 would cure the inadvertent omission of a claim which recites that the graphical user interface provides graphical objects for interfacing with an application program running on the host computer, the graphical objects including an icon, a window, and a menu.

8.28. The absence in the original Letters Patent of an independent claim in which a human-computer interface device provides tactile feedback to a user in accordance with displayed interactions between a controlled cursor and other graphical objects, including a physical object, one or more sensors, an actuator, and a microprocessor separate from the host computer and receiving force values from the host, claimed without the recital of specific elements included in claims 1-18 of the original patent, such as is provided in new claim 76 below, is an error of inadvertent omission that occurred during the drafting and prosecution of the application that matured into the present Letters Patent. At the time of drafting and prosecution of the application that matured into the present Letters Patent, we did not perceive that a device that includes the above elements should be claimed independently, without the inclusion of other elements such as are included in claims 1-18 of the present Letters Patent. To cure the aforementioned error of inadvertent omission, we therefore request the addition of a claim such as claim 76 below:

76. A human-computer interface device for controlling a graphical cursor displayed by a host computer and for providing tactile feedback to a user in accordance with displayed interactions between said cursor and other graphical objects displayed by said host computer, said interface device comprising:

a physical object to be moved by a user in two planar degrees of freedom;

one or more sensors that produce a locative signal responsive to and indicative of the position of said physical object in said two planar degrees of freedom;

a z-axis actuator that applies force to the user's hand only along a z-axis degree of freedom when current is flowed through a portion of said actuator, said z-axis degree of freedom being different from and substantially perpendicular to said two planar degrees of freedom; and

a microprocessor separate from and in communication with said host computer, said microprocessor coupled to said sensor and to said actuator, wherein said microprocessor receives desired force values from said host computer, said desired force values correlated with particular pointer locations displayed by said host computer, said microprocessor controlling current through said portion of said actuator in accordance with said received force values.

8.29. New dependent claim 77 would cure the inadvertent omission of a claim which recites that two planar degrees of freedom are x and y axes and the z-axis degree of freedom is a z axis substantially perpendicular to the x and y axes.

8.30. New dependent claim 78 would cure the inadvertent omission of a claim which recites that the interface device is a mouse device and the physical object is a mouse.

8.31. New dependent claims 79-81 would cure the inadvertent omission of claims which recite that the actuator includes a wire coil through which the current is

flowed, that the actuator includes a magnet core, and that the magnet core is an E-core.

8.32. New dependent claims 82 and 83 would cure the inadvertent omission of claims which recite that the sensor is an optical sensor, and that the sensor is an encoder.

8.33. New dependent claim 84 would cure the inadvertent omission of claims which recite that the device further includes a permanent spring coupled between the physical object and actuator.

8.34. New dependent claims 85-87 would cure the inadvertent omission of claims which recite that the actuator is controlled to indicate when the cursor displayed on the host computer is moved from one displayed menu element to another displayed menu element, that the actuator is controlled to indicate when the cursor displayed on the host computer crosses a window boundary, and that the actuator is controlled to indicate when the cursor displayed on the host computer is positioned over a graphical element.

8.35. New dependent claim 88 would cure the inadvertent omission of claims which recites that the actuator includes a portion that is moveable by the user along a z-axis to provide z-axis control to the host computer.

8.36. New dependent claims 92 and 93 would cure the inadvertent omission of claims which recite that a physical tactile element is coupled to the actuator and is moved to contact and apply pressure to the user's hand; and that the physical element applies pressure upon the user's hand by pressing upward on the hand when current is flowed through the portion of the actuator.

8.37.

8.38. We hereby appoint the following attorneys and agents to prosecute this application and transact all business in the Patent and Trademark Office connected therewith:

James R. Riegel, Reg. No. 36,651; Paul L. Hickman, Reg. No. 28,516; L. Brian R. Coleman, Reg. No. 39,145.

9. Please send all correspondence to:

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10. We hereby declare that all statements made herein of our own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

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Inventor's signature: _____.

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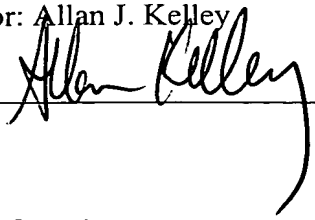
Inventor's signature: 

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AMENDED ORIGINAL CLAIMS AND NEW CLAIMS

Please cancel original claims 1-18 without prejudice.

19. An interface device for enabling a user to spatially navigate a displayed graphical menu with a displayed graphical pointer, the graphical menu having a plurality of menu elements, and for enabling said user to more easily select a menu element from said graphical menu by providing tactile feedback to said user when said graphical pointer is moved from one menu element to the next menu element in said graphical menu, said interface device comprising:

(a) a handle to be manipulated manually by a user in at least two planar degrees of freedom;

(b) a z-axis actuator generating tactile sensations to be felt by said user, wherein said z-axis actuator applies forces to the user's hand only along a z-axis degree of freedom when current is flowed through a portion of said actuator, said z-axis degree of freedom being different from and substantially perpendicular to said two planar degrees of freedom;

(c) a sensor that produces a locative signal responsive to and corresponding with the motion of said handle in said at least two degrees of freedom;

(d) a button that produces a status signal in response to being pressed by said user; and

(e) an embedded microprocessor local to said interface device and coupled to said sensor, to said button, and to said actuator, said microprocessor performing:

sending handle movement data and button data to a host computer over a communication bus such that said host computer can update displayed pointer locations with respect to said displayed graphical menu,

receiving desired force values from said host computer, said desired force values correlated with particular pointer locations displayed by said host computer, and

controlling said z-axis actuator in accordance with said received desired force values so as to provide said tactile sensations to said user that are correlated with the location of said displayed graphical pointer displayed within said graphical menu.

20. An interface device as recited in claim 19 wherein said z-axis actuator imparts said tactile sensations upon said handle along a z-axis orthogonal to said at least two degrees of freedom.

21. An interface device as recited in claim 19 wherein said handle is physically coupled to a support mechanism that is grounded and allows linear displacement between said handle and an origin.

22. An interface device as recited in claim 19 wherein said sensor is an optical sensor that includes an emitter and a detector.

23. An interface device as recited in claim 22 wherein said emitter moves when said handle is moved, projecting light upon said detector.

24. An interface device as recited in claim 23 wherein said detector detects motion of said light source in two mutually perpendicular directions.

27. An interface device as recited in claim 19 further comprising a memory that stores values that are representative of the locations of images displayed by said host computer.

28. An interface device as recited in claim 27 wherein said locations include the locations of icons displayed by said host computer.

29. An interface device as recited in claim 19 wherein said handle is a joystick.

30. An interface device as recited in claim 19 wherein said handle is a mouse.

31. An interface device as recited in claim 19 wherein said microprocessor receives display information from said host computer over said communication bus.

32. An interface device as recited in claim 19 wherein said tactile sensations include a viscous drag force.

33. An interface device as recited in claim 19 wherein said tactile sensations include an attractive force.

34. An interface device as recited in claim 33 wherein said attractive force is used to assist a user in positioning said displayed pointer into said graphical menu.

37. An interface device as recited in claim 19 wherein said z-axis actuator is a flat coil actuator.

38. An interface device as recited in claim 37 wherein the magnet associated with said at least one flat coil actuator is fixed with respect to said origin and wherein the coil moves with respect to said origin.

39. An interface device as recited in claim 19 wherein said microprocessor receives code over a communication bus from a host computer and executes said code, said communication bus including a serial interface bus.

41. A device for use in conjunction with a host computer including a computer display, said host computer displaying a graphical environment including a displayed graphical pointer controlled by said user, said device comprising:

a handle to be manipulated manually by a user in at least two planar degrees of freedom;

a z-axis actuator to generate a tactile sensation to be felt by said user, said z-axis actuator applying forces to the user's hand only along a z-axis degree of freedom when current is flowed through a portion of said actuator, said z-axis degree of freedom being different from and substantially perpendicular to said two planar degrees of freedom;

a sensor that produces a locative signal responsive to and corresponding with a position or motion of said handle in said at least two degrees of freedom;

a button that produces a status signal in response to being pressed by said user; and

control electronics local to said device and coupled to said sensor and said actuator and said button, said microcontroller performing the following:

sending handle movement data and button data to a host computer over a communication bus such that said host computer can update a displayed pointer location in said displayed graphical environment,

receiving a force value from said host computer, said force value correlated with said updated displayed pointer location, and

controlling said z-axis actuator in accordance with said received force value so as to provide said tactile sensation to said user that is correlated with the location of said displayed graphical pointer displayed within said displayed graphical environment.

42. A device as recited in claim 54 wherein said microcontroller runs a program contained, at least in part, in memory coupled to said microcontroller, and wherein said memory also stores location information which corresponds with image data from a computer display coupled to said host computer.

43. A device as recited in claim 42 wherein said location information includes information relating to the location of an icon on said graphical display.

44. A device as recited in claim 42 wherein said location information includes information relating to the location of a window on said graphical display.

45. A device as recited in claim 42 wherein said location information includes information relating to the location of a graphical button on said graphical display.

46. A device as recited in claim 42 wherein said images include a cursor interacting with another object displayed on said computer display.

47. A device as recited in claim 46 wherein said cursor interacts with an icon image displayed on said computer display.

49. A device as recited in claim 41 wherein said at least two degrees of freedom are planar, linear degrees of freedom.

51. A device as recited in claim 41 wherein said microprocessor calculates force feedback forces based on commands received from said host computer.

52. A device as recited in claim 41 wherein said handle is moveable in a plane.

53. A device as recited in claim 52 wherein said handle is also moveable along a z-axis that is approximately perpendicular to said plane.

54. A device as recited in claim 41 wherein said control electronics include an embedded microcontroller.

55. A device as recited in claim 41 wherein said tactile sensation is applied to correspond with said displayed pointer interacting with a displayed graphical menu to enable said user to more easily select a menu item from said displayed graphical menu

by providing tactile feedback to said user when said displayed graphical pointer is moved from one menu item to a next menu item in said graphical menu.

56. A device as recited in claim 41 wherein said tactile sensation is applied to correspond with said displayed pointer interacting with a displayed button.

57. A device as recited in claim 41 wherein said tactile sensation is applied to correspond with said displayed pointer interacting with a displayed window.

58. A device as recited in claim 41 wherein said tactile sensation is applied to correspond with said displayed pointer interacting with a displayed icon.

59. An interface device for use with a host computer displaying a graphical application on a display device, said host computer displaying, executing, and updating graphical objects in a graphical environment in response to user manipulation of said interface device and commanding force feedback sensations in response to said user manipulation and in coordination with said graphical objects, said graphical objects including a graphical pointer, the interface device comprising:

a physical object grasped and manipulatable by a user in two planar degees of freedom;

at least one z-axis actuator coupled to said physical object for receiving a force control signal and imparting forces along at least one degree of freedom of said physical object and in accordance with said force control signal, said forces applied along a z-axis degree of freedom that is different from and substantially perpendicular to said two planar degrees of freedom;

a sensor that detects motion of said physical object along said at least one degree of freedom and outputs signals relating to the position of said physical object;

a user-adjustable switch apparatus providing a state signal representing a state of said switch apparatus; and

a microprocessor local to said interface apparatus, separate from said host computer, and coupled to said host computer, to said sensor, and to said switch apparatus, said microprocessor receiving

force values from said host computer, said force values correlated with particular locations of said graphical pointer in said graphical environment displayed by said host computer,

said state signal from said switch apparatus, and

said signals from said sensor,

said microprocessor executing a process in parallel with said host execution of said graphical application and providing said force control signal to said at least one actuator to impart said forces in accordance with said received force values so as to provide tactile sensations to said user that are correlated with the location of said displayed graphical pointer.

60. The interface device claimed in claim 59 wherein said graphical objects include a displayed graphical menu, wherein said tactile sensations enable said user to more easily select a menu element from said displayed graphical menu by providing said tactile sensations to said user when said graphical pointer is moved from one menu element to the next menu element in said graphical menu.

63. A method for controlling a force feedback interface device using a host computer, said interface device manipulated by a user, a display device coupled to said host computer displaying a graphical user interface including images and updating said graphical user interface in response to said manipulation of said interface device, said interface device conveying force feedback sensations to said user in response to said manipulations, the method comprising:

sending a position signal to said host computer, said position signal including information representative of the motion or position of a handle of said interface device in two planar degrees of freedom, said handle being physically manipulated by said user, wherein said host computer updates the location of a cursor within said graphical user interface in response to said position signal;

receiving a force value from said host computer with a microprocessor local to said force feedback interface device, said force value correlated with said location of said cursor; and

controlling a z-axis actuator in accordance with said received force value to provide a tactile sensation to said user that is correlated with said location of said cursor in said graphical user interface, said tactile sensation being applied to the user's hand along a z-axis degree of freedom, said z-axis degree of freedom being different from and substantially perpendicular to said two planar degrees of freedom.

64. A method as recited in claim 63 wherein a sensor signal is input to said microprocessor, said microprocessor calculating said position signal based on said sensor signal, said microprocessor sending said position signal to said host computer.

65. A method as recited in claim 63 wherein said handle includes a joystick that can be moved by said user in two degrees of freedom.

66. A method as recited in claim 64 wherein said graphical user interface provides graphical objects for interfacing with an application program running on said host computer, said graphical objects including an icon, a window, and a menu.

76. A human-computer interface device for controlling a graphical cursor displayed by a host computer and for providing tactile feedback to a user in accordance with displayed interactions between said cursor and other graphical objects displayed by said host computer, said interface device comprising:

a physical object to be moved by a user in two planar degrees of freedom;

one or more sensors that produce a locative signal responsive to and indicative of the position of said physical object in said two planar degrees of freedom;

a z-axis actuator that applies force to the user's hand only along a z-axis degree of freedom when current is flowed through a portion of said actuator, said z-axis degree of freedom being different from and substantially perpendicular to said two planar degrees of freedom; and

a microprocessor separate from and in communication with said host computer, said microprocessor coupled to said sensor and to said actuator, wherein said microprocessor receives desired force values from said host computer, said desired force values correlated with particular pointer locations displayed by said host computer, said microprocessor controlling current through said portion of said actuator in accordance with said received force values.

77. An interface device as recited in claim 76 wherein said two planar degrees of freedom are x and y axes parallel to a flat surface on which said interface device rests and said z-axis degree of freedom is substantially perpendicular to said x and y axes.

78. An interface device as recited in claim 76 wherein said interface device is a mouse device and wherein said physical object is a mouse.

79. An interface device as recited in claim 76 wherein said actuator includes a wire coil through which said current is flowed.

80. An interface device as recited in claim 79 wherein said actuator includes a magnet core.

81. An interface device as recited in claim 80 wherein said magnet core is an E-core.

82. An interface device as recited in claim 76 wherein said sensor is an optical sensor.

83. An interface device as recited in claim 82 wherein said sensor is an encoder.

84. An interface device as recited in claim 80 further comprising a permanent spring coupled between said physical object and said actuator.

85. An interface device as recited in claim 76 wherein said actuator is controlled to indicate when the cursor displayed on the host computer is moved from one displayed menu element to another displayed menu element.

86. An interface device as recited in claim 76 wherein said actuator is controlled to indicate when the cursor displayed on the host computer crosses a window boundary.

87. An interface device as recited in claim 76 wherein said actuator is controlled to apply said pressure to said user's hand to indicate when the cursor displayed on the host computer is positioned over a graphical element.

88. An interface device as recited in claim 76 wherein said actuator includes a portion that is moveable by said user along a z-axis to provide z-axis control to said host computer.

92. An interface device as recited in claim 76 wherein a physical tactile element is physically coupled to said actuator and is moved to contact and apply pressure to said user's hand.

93. An interface device as recited in claim 92 wherein said physical element applies pressure upon the user's hand by pressing upward on said hand when said current is flowed through said portion of said actuator.